Final Report

FNAS/Radiative Transfer Models

Most atmospheric constituents exhibit vibrational-rotational transitions in the infrared spectral region (10-4000 cm^{-1}), which may be observed in emission or absorption with high sensitivity and high spectral resolution spectrometers. The observed spectrum of the earth's atmosphere, for example, includes spectral features of the trance gases O_3, CO_2, H_2O, HO_2, OH, N_2O, NO, HNO_3, N_2O_5, ClO, $ClONO_2$, HF, Freons, HCl, and HCN. An understanding of the photochemical and dynamical process involving these gases is necessary for resolving some of the basic atmospheric issues such as the questions relating to the depletion of stratospheric ozone. The infrared thermal emission spectra of the planetary atmospheres observed from ground-based as well as from space missions also show spectral features of most of their major and minor constituents. The spectrum of Saturn's atmosphere observed by Voyager, for example, show the spectral features of its major constituent H_2 as well as trance gases such as CH_4, NH_3, PH_3, C_2H_2, and C_2H_6. The observed spectrum of the atmosphere of Saturn's largest satellite Titan, exhibits a broad pressure induced continuum absorption of its major constituent N_2 as well as the spectral features of some complex hydrocarbons (C_2H_2, C_2H_4, C_2H_6, C_3H_4, etc.) and nitrites (HCN, HC_3N, C_2N_2, etc.). Comprehensive studies of the chemical composition and the thermal structure of planetary atmospheres is crucial to an understanding of the origin and the evolution of atmospheres.

A detailed analysis of the observed infrared spectra provides a wealth of information about the physical and chemical processes in atmospheres. A primary requirement for interpretation of the observed data is the availability of radiative transfer models capable of calculating the observed radiation for realistic atmospheric and observational conditions, and analytical inversions programs for retrieval of vertical temperature and gas concentration profiles. This research program at MSFC focuses on the development and applications of infrared radiative transfer

models and inversion methods for interpretation of data obtained from various NASA missions for studies of the physics and chemistry of the atmospheres of the earth and the planets.

The inversion programs for retrieval of pressure-temperature (P-T) profiles from infrared solar absorption spectra obtained from orbiting space shuttle platforms have been developed and tested for synthetic data. These programs are currently being evaluated for retrieval of PT profiles from observations made by the ATMOS experiment on ATLAS1-2 Shuttle missions carried out in 1992 and 1993. Infrared radiative transfer models and rapid inversion techniques are also being applied for interpretation of observations to be made with the Composite Infrared Spectrometer (CIRS) from the Cassini Orbiter to be launched for studies of Saturn and its satellites. Preliminary studies for an analysis of the expected data from observations of Saturn and Titan are being carried out at the present time.

The infrared radiative transfer models for planetary atmospheres are also being employed in a program focusing on the development of photometric standards for observations of astronomical sources from the Infrared Space Observatory (ISO). An observational program employing the Kuiper Airborne Observatory (KAO) for photometric flux measurements of the planets Uranus, Neptune, and Mars.

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